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# CHLOROPHYLL SYNTHESIS, GROWTH AND YIELD PERFORMANCE OF SUMMER MUNGBEAN CV. BARI MOOG-6 IN RESPONSE TO BAP AND NAA

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## Abstract

Effects of plant growth regulators (PGRs) on physiology, growth and yield attributes of summer mungbean (*Vigna radiata* L.) CV. BARI moog-6 were investigated. Two PGRs, namely NAA and BAP with three concentrations of each *viz.,* 50, 100, 150 ppm and fresh water as control were applied as foliar spraying at vegetative and pre-flowering stage. Application of BAP and NAA had positive impact on the morpho-physiological characteristics of summer mungbean. Spraying of PGRs at 150 ppm showed the highest performance regarding plant height, number of leaves per plant, leaf length, leaf breadth, root nodule number, chlorophyll and carotenoid contents, pod length, and seed yield of mungbean. Spraying BAP at 150 ppm concentration produced the highest seed yield (1.56 t/ha) followed by 150 ppm NAA (1.54 t/ha).

## Introduction

Mungbean (*Vigna radiata* L.) is an important pulse crop worldwide containing high quality and quantity protein (Tomooka *et al.* 2002). It is a short duration crop and can be grown twice a year. Besides providing valuable protein in the diet, it helps to fix atmospheric nitrogen to the root rhizobia and enrich the soil (BINA 2004). In a developing country like Bangladesh, pulse can improve the overall nutritional value of cereals based diet. In this country, planting mungbean gives the highest yield in summer (Satter and Ahmed 1995). In a developing country like Bangladesh, pulse can improve the overall nutritional value of cereal based diet but unfortunately, there is an acute shortage of grain legumes production in the country. Mungbean has special importance in intensive crop production system of the country for its short growing period (Ahmed *et al.* 1978).

In Bangladesh, mungbean grows well all over the country except the district of Khagrachari and Rangamati (BBS 2010). The acreage and production of mungbean is very low. Average yield is as low as 689 kg/ha (BBS 2011) but its production needs to be increased more than three folds (BARI 2000). More than 3 t/ha of seed yield have been reported in many trials in improved pulses growing countries. Several strategies have been initiated to boost up the productivity of mungbean. Application of plant growth regulators is one of the effective measures to increase the yield of many crops. They are being used as an aid to change the morphological characteristics and enhance yield in many crops (Nickell 1982, Sarkar *et al.* 2002, Sarker *et al.* 2009, Bakhsh *et al.* 2011). Plant growth regulators generate metabolic and physiological responses in plants by affecting their growth and development (Hayat *et al.* 2010). Many research works have been carried out with plant growth regulators (PGR) in different crops all over the world. But in Bangladesh research work with PGR on changing the morphological and physiological characteristics for yield increase of mungbean is limited. Thus attempts were made to investigate the vegetative growth, chrolophyll synthesis, number of root nodules and seed yield in response to BAP and NAA application.

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**Materials and Methods**

The experiment was conducted in the research farm of Hajee Mohammad Danesh Science and Technology University, Dinajpur. Land was fertilized by urea, triple super phosphate (TSP) and muriate of potash (MOP) at 45, 100 and 55 kg/ha, respectively (Afzal *et al.* 1999). After sowing of seeds, weeding followed by thinning was done at 20 and 40 days after sowing (DAS). The plots were irrigated as and when necessary. Proper plant protection measures were taken to protect plants from pest and diseases. The PGRs - BAP and NAA were sprayed at 50 ppm (T2), 100 ppm (T3) and 150 ppm (T4) at vegetative and pre-flowering stages. Fresh water was sprayed as control (T1). The experiment was laid out in a completely randomized block design (CRBD). Three plants randomly selected from each plot were uprooted carefully to ensure no root damage and the root nodule numbers were counted at 20, 40 and 60 DAS. Three plants from each plot were selected randomly and data were taken at 20, 40, 60 and 80 DAS on the following traits- plant height, number of leaves per plant, leaf length, and leaf breadth, respectively. The chlorophyll pigments (Chlorophyll a,b and carotenoid) of mungbean leaf were determined from the young leaves at flowering stage by the method described by Arnon (1949). Among yield components, data of pod length, number of seed/pod, and seed yield were recorded. The collected data were analyzed statistically using the ANOVA technique with the help of computer by MSTAT-C program. The treatment means were compared by DMRT (Gomez and Gomez 1984) at 5% level of significance.

**Results and Discussion**

Effects of BAP and NAA application at different levels on plant height of summer mungbean are presented in Table 1. Plant height was significantly influenced ($p \leq 0.05$) at all growth stages under BAP and NAA application. Results revealed that plant height increased with the increase of concentration of BAP and NAA which were sprayed twice at vegetative and pre-flowering stage. The highest plant height was recorded with spraying 150 ppm ($T_4$) followed by 100 ppm ($T_3$) and 50 ppm ($T_2$) at all growth stages except 20 DAS with NAA but statistically similar. Among the different levels of NAA, the tallest plant was recorded using 150 ppm ($T_4$) followed by 100 ppm ($T_3$) and 50 ppm ($T_2$). The shortest plant height was recorded in case of control treatment ($T_1$). Application of 150 ppm ($T_4$) NAA increased plant height 10.33% than the control while 150 ppm ($T_4$) of BAP increased 17.91% than control which was 3.89% higher than that of corresponding level of NAA. The PGRs (BAP and NAA) treated plants showed increased plant height over control. This might be due to increased number of internodes or length of internodes because of increased cell numbers. The result is in agreement with the findings of Ferdous *et al.* (2012).

The foliar spraying of BAP and NAA had significant effect on leaf number/plant of summer mungbean at different growth stages (Table 2). Results revealed that number of leaves/plant increased up to 60 DAS followed by decline perhaps due to leaf shedding and aging.

The increment of leaf number varied significantly due to application of different levels of BAP and NAA. Among the different levels of BAP, 150 ppm showed the best performance and significantly differed with the other levels of BAP. The highest leaf number was found using 150 ppm followed by 100 and 50 ppm which differed significantly at 80 DAS. In contrast, control treatment had the lowest number of leaves/plant but statistically similar with 50 ppm. Similarly, spraying NAA at 150 ppm had the best performance producing more leaves and differed significantly with the other levels of NAA at 80 DAS among the different combinations but less than BAP. The highest leaf number (7.34/plant) was recorded at 150 ppm at 60 DAS followed by 100 and 50 ppm while the lowest leaf number (6.42/plant) was recorded with the control treatment at 60 DAS. This result is in agreement with the findings of Ferdous *et al.* (2012). The treatment of 150 ppm BAP increased leaf number 29.83% than control and 150 ppm of NAA increased 22.44%

than control treatment, respectively. The stimulatory effect was 9.32% higher in BAP than that of corresponding level of NAA which indicated that BAP had more stimulatory effect on leaf number compared to NAA.

**Table 1. Plant height (cm) of summer mungbean under different levels of BAP and NAA at different days after sowing (DAS).**

| Treatments | | Days after sowing (DAS) | | | |
|---|---|---|---|---|---|
| PGR | Level | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| BAP | $T_1$ | 7.4 ab ± 1.69 | 27.59 ab± 3.58 | 41.53 b ± 3.42 | 43.27 d ± 3.41 |
| | $T_2$ | 7.54 ab ± 0.60 | 28.08 ab ± 2.55 | 45.57 ab ± 2.59 | 48.16 abc ± 3.09 |
| | $T_3$ | 7.59 ab ± 1.23 | 31.06 ab ± 2.24 | 45.6 ab ± 2.15 | 49.04 ab ± 3.28 |
| | $T_4$ | 8.53 a ± 1.42 | 32.70 a ± 2.18 | 48.39 a ± 3.91 | 51.02 a ± 3.76 |
| NAA | $T_1$ | 6.86 b ± 1.29 | 25.58 b ± 2.63 | 42.76 b ± 3.34 | 44.51 cd ± 2.67 |
| | $T_2$ | 6.63 b ± 1.29 | 27.06 b ± 2.45 | 44.06 ab ± 3.25 | 45.90 bcd ± 3.36 |
| | $T_3$ | 6.82 b ± 1.78 | 27.22 ab ± 3.40 | 44.45 ab ± 3.04 | 46.78 abcd ± 3.19 |
| | $T_4$ | 6.23 b ± 1.16 | 27.57 ab ±2.67 | 45.04 ab ± 3.15 | 49.11 ab ± 3.41 |
| $LSD_{0.05}$ | | 1.374 | 5.067 | 4.124 | 3.871 |
| CV (%) | | 7.99 | 8.47 | 6.26 | 5.59 |

Figures having the same letter (s) do not differ significantly at $p \leq 0.05$ by DMRT.

**Table 2. Number of leaves/plant of summer mungbean under different levels of BAP and NAA at different days after sowing (DAS).**

| Treatments | | Days after sowing (DAS) | | | |
|---|---|---|---|---|---|
| PGR | Level | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| BAP | $T_1$ | 3.17 a ± 0.29 | 4.92 c ± 0.43 | 6.50 b ± 1.26 | 5.33 bc ± 1.15 |
| | $T_2$ | 3.08 a ± 0.14 | 5.0 c ± 0.29 | 6.51 b ± 0.66 | 5.42 bc ± 0.54 |
| | $T_3$ | 3.25 a ± 0.29 | 5.17 bc ± 0.39 | 6.58 b ± 1.55 | 5.92 abc ± 0.87 |
| | $T_4$ | 3.08 a ±0.14 | 6.17 a ± 0.58 | 8.42 a ± 1.72 | 6.92 a ± 1.29 |
| NAA | $T_1$ | 3.08 a ± 0.14 | 4.58 c ± 0.58 | 6.42 b ± 0.43 | 5.17 c ± 0.68 |
| | $T_2$ | 3.08 a ± 0.14 | 4.75 c ± 0.43 | 6.50 b ± 0.68 | 5.33 bc ± 0.87 |
| | $T_3$ | 3.08 a ± 0.14 | 5.17 bc ± 0.43 | 6.58 b ± 0.89 | 5.42 bc ± 0.43 |
| | $T_4$ | 3.25 a ± 0.29 | 5.83 ab ± 0.39 | 7.34 ab ± 0.83 | 6.33 ab ± 1.15 |
| $LSD_{0.05}$ | | 0.315 | 0.734 | 1.321 | 0.975 |
| CV (%) | | 6.87 | 9.68 | 13.11 | 11.58 |

Figures having the same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT.

The stimulatory effect of growth hormones and their different concentrations on leaf length of BARI moog-6 was observed at all growth stages and showed statistically significant at $p \leq 0.05$ (Table 3). Among different concentrations of BAP, the highest leaf length was found using 150 ppm at all growth stages. Control treatment also had statistically higher leaf length in the present study. Likewise BAP, NAA spraying with 150 ppm produced the highest leaf length which differed significantly with the other levels of NAA during their growing period.

**Table 3. Leaf length of summer mungbean under different levels of BAP and NAA at different DAS.**

| Treatments | | Days after sowing | | | |
|---|---|---|---|---|---|
| PGR | Level | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| BAP | $T_1$ | 3.45 ab ± 0.43 | 7.38 bc ± 0.94 | 9.96 ab ± 0.87 | 10.29 ab ± 0.97 |
| | $T_2$ | 3.33 bc ± 0.52 | 7.7 bc ± 0.87 | 10.07 ab ± 0.97 | 10.40 ab ± 0.94 |
| | $T_3$ | 3.42 ab ± 0.64 | 8.20 ab ± 0.68 | 10.10 ab ± 0.94 | 10.51 ab ± 0.86 |
| | $T_4$ | 2.93 e ± 0.66 | 9.09 a ± 0.92 | 10.91 a ± 0.79 | 10.97 a ± 0.71 |
| NAA | $T_1$ | 3.19 cd ± 0.55 | 6.75 c ± 0.65 | 9.43 b ± 0.53 | 9.86 b ± 68 |
| | $T_2$ | 3.58 a ± 0.55 | 6.94 c ± 0.62 | 10.15 ab ± 0.87 | 10.46 ab ± 0.94 |
| | $T_3$ | 3.13 d ± 0.57 | 7.75 bc ± 0.97 | 10.26 ab ± 0.79 | 10.54 ab ± 0.87 |
| | $T_4$ | 3.09 d ± 0.38 | 8.41 ab ± 0.71 | 10.28 ab ± 0.61 | 10.86 ab ± 0.94 |
| $LSD_{0.05}$ | | 0.147 | 0.949 | 1.018 | 0.729 |
| CV(%) | | 3.14 | 8.31 | 6.82 | 4.75 |

Figures having the same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT

At 60 DAS and 80 DAS, the 150, 100 and 50 ppm found to be statistically similar in the both treatments. Likewise plant height and leaf number, the leaf length of summer mungbean cv. BARI moog-6 was more responsive to BAP than those of corresponding NAA, respectively but not significant. Application of 150 ppm BAP increased leaf length 1.01% higher than the corresponding level of NAA. The present findings are in agreement with Ferdous *et al.* (2012).

Application of plant growth regulators at 150 ppm resulted in higher leaf breadth than the other levels of BAP and NAA (Table 4). The lowest leaf breadth was found in control treatment which was statistically similar with 50 and 100 ppm at 60 DAS (Table 4). Application of 150 ppm of BAP was found to increase the leaf breadth more than the similar level of NAA but both levels were statistically similar. 150 ppm of BAP increased leaf breadth to 1.29% than the similar treatment of NAA. By observing the results, it can be concluded that compared to NAA, BAP had more positive effect on the leaf breadth of summer mungbean.

The number of biologically N-fixing root nodule produced by summer mungbean cv. BARI moog-6 was enhanced interestingly under BAP and NAA (Table 5). The increment of nodule number varied significantly due to application of different concentrations of BAP and NAA. Among the different levels of BAP, highest number of root nodule was found with the application of 150 ppm at 40 DAS and 60 DAS followed by 100 and 50 ppm. Lowest number of nodules was found in plants with the control treatment throughout the growing period. Similarly, among the different levels of NAA, application of 150 ppm found to produce the highest number of nodules in mungbean plant than the other levels of NAA throughout the growing period.

Increasing effect of root nodule under NAA application was also reported by Ferdous *et al.* (2012).Application of 150 ppm BAP increased 55.91% nodule number and the same level of NAA increased root nodules 45.01% than the control, respectively at 40 DAS. This influencing effect was 1.38% higher in BAP than NAA. The present findings suggested that more root nodule produced by BAP and NAA might nourish N-requirement for the mungbean plant growth. The higher number of root nodule usually beneficial for fixing atmospheric-N by *Rhizobium* bacteria.

**Table 4. Leaf breadth of summer mungbean under different levels of BAP and NAA at different DAS.**

| Treatments | | Days after sowing (DAS) | | | |
|---|---|---|---|---|---|
| PGR | Level | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| BAP | $T_1$ | 1.99 a ± 0.35 | 5.76 cd ± 0.74 | 7.81 ab ± 0.84 | 8.03 a ± 0.97 |
| | $T_2$ | 1.95 a ± 0.27 | 5.98 cd ± 0.83 | 7.92 ab ± 0.63 | 8.113 a ± 0.87 |
| | $T_3$ | 1.96 a ± 0.45 | 6.42 bc ± 0.82 | 8.06 ab ± 0.87 | 8.21 a ± 0.94 |
| | $T_4$ | 1.80 a ± 0.34 | 7.33 a ± 0.86 | 8.53 a ±0.94 | 8.67 a ± 0.97 |
| NAA | $T_1$ | 1.83 a ± 0.27 | 5.26 d ± 0.69 | 7.35 b ± 0.69 | 7.58 a ± 0.87 |
| | $T_2$ | 2.14 a ± 0.34 | 5.50 d ± 0.62 | 7.86 ab ± 0.72 | 8.33 a ± 0.94 |
| | $T_3$ | 1.90 a ± 0.29 | 5.92 cd ± 0.67 | 8.03 ab ± 0.50 | 8.41 a ± 0.83 |
| | $T_4$ | 1.78 a ± 0.15 | 6.90 ab ± 0.75 | 8.43 a ± 0.84 | 8.56 a ± 0.97 |
| $LSD_{0.05}$ | | 0.339 | 0.831 | 0.965 | 1.415 |
| CV ( % ) | | 11.96 | 9.21 | 8.24 | 11.78 |

Figures having the same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT.

**Table 5. Root nodule number of summer mungbean under different levels of BAP and NAA at different DAS.**

| Treatments | | Days after sowing | | |
|---|---|---|---|---|
| PGR | Level | 20 DAS | 40 DAS | 60 DAS |
| BAP | $T_1$ | 11.59 a ± 2.89 | 27.42 f ± 3.91 | 25.67 e ± 3.71 |
| | $T_2$ | 10.17 a ± 2.29 | 35.92 cd ± 3.01 | 29.83 c ± 3.14 |
| | $T_3$ | 11.09 a ± 2.65 | 38.42 abc ± 2.98 | 33.25 b ± 3.38 |
| | $T_4$ | 10.17 a ± 2.93 | 42.75 a ± 3.14 | 37.67 a ± 2.94 |
| NAA | $T_1$ | 12.25 a ± 2.38 | 29.08 e ± 3.27 | 26.42 d ± 3.08 |
| | $T_2$ | 11.34 a ± 3.34 | 34.08 d ± 3.69 | 29.67 c ± 3.77 |
| | $T_3$ | 8.583 a ± 2.91 | 37.25 bc ± 3.14 | 30.42 c ± 2.96 |
| | $T_4$ | 10.17 a ± 2.23 | 42.17 a ± 3.28 | 37.92 a ± 3.26 |
| $LSD_{0.05}$ | | 3.14 | 4.56 | 2.38 |
| CV (%) | | 11.17 | 8.73 | 6.29 |

Figures having the same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT.

Effects of different levels of BAP and NAA varied markedly in chlorophyll-a content of mungbean (Table 6). Among the different levels of BAP highest chlorophyll-a content was found with the application of 150 ppm followed by 100 and 50 ppm which differed statistically. Similarly, among the different levels of NAA sprayed, chlorophyll-a content was higher with the application of 150 ppm followed by 100 and 50 ppm but statistically similar. The control treatment was found to produce the lowest amount of chlorophyll-a content in summer mungbean compared to the different levels of PGRs. Application of 150 ppm of BAP was statistically higher than the same level of NAA.

**Table 6. Chlorophyll and carotenoid contents of summer mungbean under different levels of BAP and NAA at flowering stage.**

| Treatment | | Chlorophyll contents | | | |
|---|---|---|---|---|---|
| PGRs | Level | Chl-a (mg/g) | Chl-b (mg/g) | Total chlorophyll (mg/g) | Total carotenoid (mg/g) |
| BAP | $T_1$ | 10.85 b ± 1.25 | 2.272 c ± 0.20 | 13.12 c ± 1.44 | 1.326 a ± 0.05 |
| | $T_2$ | 11.09 b ± 0.97 | 2.518 c ± 0.30 | 13.61 c ± 0.07 | 1.274 a ± 0.09 |
| | $T_3$ | 12.66 ab ± 2.22 | 3.963 a ± 0.61 | 16.62 ab ± 1.68 | 1.273 a ± 0.08 |
| | $T_4$ | 13.53 a ± 0.91 | 4.153 a ± 0.39 | 17.68 a ± 0.97 | 1.076 b ± 0.04 |
| NAA | $T_1$ | 11.33 b ± 1.04 | 2.750 c ± 0.19 | 14.08 bc ± 1.09 | 1.229 a ± 0.04 |
| | $T_2$ | 12.38 ab ± 1.46 | 2.690 c ± 0.26 | 15.07 b ± 0.99 | 1.311 a ± 0.06 |
| | $T_3$ | 12.55 ab ± 1.04 | 3.281 b ± 0.19 | 15.83 ab ± 0.43 | 1.194 ab ±0.05 |
| | $T_4$ | 12.59 ab ± 0.42 | 4.051 a ± 0.27 | 16.64 a ± 1.51 | 1.051 b ± 0.05 |
| $LSD_{0.05}$ | | 1.862 | 0.488 | 2.076 | 0.132 |
| CV (%) | | 10.45 | 10.34 | 9.24 | 7.45 |

Figures having the same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT.

Effects of different levels of BAP and NAA were Significant on chlorophyll-b content of mungbean (Table 6). The highest chlorophyll-b content was found with the application of 150 ppm followed by 100 and 50 ppm of PGRs. Lowest amount of chlorophyll-b content was found in the plants with control treatment. Application of 150 ppm of BAP found to produce little higher amount of chlorophyll-b than the same level of NAA but both were statistically similar. However, chlorophyll-a and chlorophyll-b contained in leaves of higher plants are the main pigments of photosynthesis in the chloroplasts, and have important functions in the absorption and exploitation of the light energy, thereby influence photosynthetic efficiency (Pan and Dong 1995). Some studies have demonstrated that chlorophyll content is positively correlated with photosynthetic rate (Araus *et al.* 1997, Thomas *et al.* 2005).

Different levels of plant growth regulators- BAP and NAA had significant effect on total carotenoid content of mungbean (Table 6). Among the different treatments of BAP, highest carotenoid content was found in plants treated with control treatments but was statistically similar with 100 and 50 ppm. While considering the different levels of NAA, highest carotenoid content was found with the control treatment followed by 50 and 100 ppm. Lowest amount of carotenoid was found with the treatment of 150 ppm of NAA. Total carotenoids have additional roles and partially help the plants to withstand adversaries of drought (Farooq *et al.* 2009).

Effects of different concentrations of BAP and NAA application on pod length are presented in Table 7 and a significant effect of different levels of plant growth regulators was found on pod length. Among the different levels of BAP highest pod length was found with the application of 150 ppm followed by 100 and 50 ppm. The treatment of 100 ppm was statistically similar with 150 ppm while 50 ppm differed statistically with the former two levels. Similarly, among the different levels of NAA, application of 150 ppm found to produce the highest pod length in mungbean plant than the other levels of NAA and significantly differed with the other levels of NAA. The control treatment produced the lowest pod length in summer mungbean compared to the different levels of NAA. Application of 150 ppm of BAP was statistically similar with the same level of NAA. Application of 150 ppm of BAP increased pod length by 2.73% while the same level of NAA increased pod length by 2.64% than the control treatment, respectively. The stimulatory effect was 0.97% higher in BAP than that of NAA. Similar stimulatory effect was also reported by Ferdous *et al.* (2012).

**Table 7. Seed yield and yield contributing characteristics of summer mungbean under different levels of BAP and NAA at harvesting stage.**

| Treatment | | Pod length (cm) | Number of seed/pod | Total yield ( t/ha) |
|---|---|---|---|---|
| PGRs | Level | | | |
| BAP | $T_1$ | 9.14 ab ± 0.73 | 11.18 b ± 1.40 | 1.247 b |
| | $T_2$ | 9.18 ab ± 0.80 | 11.45 ab ± 1.97 | 1.361 ab |
| | $T_3$ | 9.34 a ± 0.63 | 11.65 ab ± 1.64 | 1.414 ab |
| | $T_4$ | 9.39 a ± 1.02 | 11.83 a ± 1.66 | 1.564 a |
| NAA | $T_1$ | 9.06 bc ± 1.02 | 11.20 b ± 1.39 | 1.239 b |
| | $T_2$ | 9.03 b ± 0.89 | 11.47 ab ± 1.26 | 1.272 b |
| | $T_3$ | 9.08 ab ± 0.96 | 11.59 ab ± 1.63 | 1.386 ab |
| | $T_4$ | 9.30 a ± 0.77 | 11.80 a ± 1.58 | 1.549 a |
| $LSD_{0.05}$ | | 0.628 | 0.427 | 0.186 |
| CV (%) | | 4.67 | 6.68 | 9.23 |

Figures having the same letter or without letter (s) do not differ significantly at $p \leq 0.05$ by DMRT.

Table 7 showed significant increase of seed number/pod with the increase of the concentrations of BAP and NAA. Among the different levels of BAP, highest number of seeds was found with the application of 150 ppm followed by 100 and 50 ppm. Similarly, among the different levels of NAA, application of 150 ppm found to produce the highest number of seeds per pod in mungbean plant than the other levels of NAA and significantly differed with the other levels of NAA. Next to this level of NAA, seed number per pod was found with 100 ppm followed by 50 ppm. The control treatment found to produce the lowest number of seeds per pod in summer mungbean compared to the different levels of BAP and NAA. Application of 150 ppm of BAP increased seed number by 5.81% and NAA increased 5.36% than that of control treatment. The stimulatory effect was 0.25% higher in BAP than that of NAA. Arora *et al.* (1998) reported that application of NAA increased the number of seeds in chickpeas. Similar findings were also reported by Ferdous *et al.* (2012).

The foliar application of BAP and NAA on seed yield in summer mungbean presented in Table 7 shows a significant variation in the seed yield in summer mungbean due to different levels of plant growth regulators. Results revealed that the seed yield increased with the increase of the concentrations of BAP and NAA, respectively. Among the different levels of BAP, highest yield (1.56 t/ha) was found with the application of 150 ppm which differed statistically with other levels followed by 100 and 50 ppm which were at similar statistical ranking. Similarly, among the different levels of NAA, application of 150 ppm found to produce the highest yield (1.55 t/ha) in mungbean than the other levels of NAA and significantly differed with the other levels of NAA. The control treatment was found to produce the lowest yield in summer mungbean compared to the different levels of PGRs.

Application of 150 ppm of BAP was statistically similar with the same level of NAA but numerically the yield was little higher with BAP than the same level of NAA. The 25.42% increased yield was found with the application of 150 ppm of BAP than control while with the same level of NAA, i.e., 150 ppm gave 25.02% increased yield in summer mungbean than the control treatment, respectively. The stimulatory effect regarding yield was 0.97% higher in BAP than NAA. The finding is also in well agreement with the observations made by Ferdous *et al.* (2012). The BAP and NAA applications had profound influence upon the morphological and physiological characteristics on summer mungbean. Either BAP or NAA application at 150 ppm at vegetative and pre-flowering stages had remarkable influence for plant growth, yield and yield contributing characteristics of mungbean. Increased root nodule formation might benefit to add biological $N_2$ to soil resulting in eco-friendly N-nutrition in soil. The increased amount of chlorophyll-a, -b, and total chlorophyll had positive role in preparing photosynthates which in turn help in improving growth and yield in summer mungbean. Therefore, the twice spraying of BAP @150 ppm performed better over NAA for maximizing summer mungbean cv. BARI moog-6.

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